

tion that ends the volume may be the most important contribution of the work.

In toto, this is an encyclopedic literature review in which the biology is often well integrated with physical, paleontological, geochemical, and climatological processes. Laws and the authors have been immensely successful with their objectives. I wish that Laws had included a chapter on Holocene geology, because coastal biologists must be cognizant of recent patterns of glaciation, local isostasy, and sea-ice and sea-level fluxes. Also useful might have been a biogeographical chapter addressing the age and geographical sources of marine species, both planktonic and benthic, as is done for terrestrial plants in volume 1. Missing also is an account of the rich history of Antarctic ecology. The accomplishments of the early naturalists under ghastly conditions represent some of the highest points in our literature—who among the readers of these volumes has not thrilled at Cherry-Garrard's rendition of E. A. Wilson's activities in *The Worst Journey in the World*? A brief history of the accomplishments of the early naturalists and the *Discovery* expeditions would have added an important dimension to this work. Finally, for the large number of antarctic aficionados, especially those working on the various large international Southern Ocean projects, there will be an inevitable sense of *déjà vu*, for several of the authors in these volumes, especially T. D. Foster, I. Everson, and Laws, have written many quite similar reviews on their subjects.

The publication was conceived by Academic Press as an updating of their 1970 book of the same title, which was the proceedings of the 1968 Second Symposium on Antarctic Research. A comparison with that and the several subsequent symposiums that have been held is unavoidable. Laws notes that the present treatment of antarctic ecology has the "advantage of planning a more balanced account" than proceedings volumes, which he claims are unplanned, with their contents depending on what happens to be offered. Missing by design, however, is the international flair, the zest, and the novel thinking (often associated with graduate students) of the symposiums. There is a tendency to look to reviews to point in new research directions, but in most of these chapters the emphasis is descriptive and the research suggestions that are offered tend to be in the direction of filling in of holes in the factual tapestry rather than the deductive leaps and bold conjectures important in science.

These quibbles notwithstanding, this is an excellent and important publication that will be of great use for many years to come.

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## Startle Circuits

**Neural Mechanisms of Startle Behavior.** ROBERT C. EATON, Ed. Plenum, New York, 1984. xx, 377 pp., illus. \$49.50.

In contemporary neurobiology there is a keen and widespread interest in relating neurons and neural networks to behavior. The ultimate goal of this endeavor is to try to uncover common neural mechanisms that can teach us some of the general principles that underlie the neural organization of behavior. But how might we search for general principles among the almost bewildering number of animals, behaviors, and nervous systems that it is possible to analyze? One approach is exemplified by *Neural Mechanisms of Startle Behavior*. Startle behaviors are short-latency, fast motor acts that occur in response to stimuli having a sudden or an unexpected onset. What emerges from the book is that startle circuits can provide an extremely useful comparative vantage point for examining the mechanisms by which phylogenetically diverse nervous systems have solved a fundamental problem in adaptive behavior: the need to respond rapidly to potentially threatening stimuli. The contributors to the volume study animals ranging from jellyfish to rodents and use approaches ranging from cellular neurophysiology and anatomy to neurogenetics and neuropharmacology. But because they all focus on the elements common to startle circuits, some important themes emerge about properties of neural circuits involved in the initiation of behavior.

One of the most pervasive themes concerns the role of giant fibers in mediating startle and rapid escape responses. As is clear from Bullock's lucid introductory chapter, it has long been appreciated that large-diameter fibers contribute to startle and escape in a wide variety of species. However, the view that all giant fibers are functionally alike and simply act to initiate behavior (the neural equivalent of a starter's pistol at a track meet) is quickly dispelled by several enlightening examples. Ritzmann discusses compelling evidence in the cockroach that

the ventral giant interneurons provide the principal initiation signal for most escape responses and that the dorsal giant interneurons provide a bifunctional pathway that, in response to wind stimuli, triggers directed escape running when the legs are in contact with the ground and flight when they are not. Krasne and Wine show clearly that in the crayfish the medial giants, which have a rostral receptive field, trigger a tail flip that drives the animal backward away from the rostral threat whereas the lateral giants, which have a caudal receptive field, trigger a response that lifts the animal and pivots it forward, away from the eliciting stimulus. Similarly, Drewes describes how in earthworms the difference in receptive fields for the medial giant fiber (anterior-sensitive) and the lateral giant fiber (posterior-sensitive) can explain differential rapid withdrawal responses to directed stimuli. Further important insights into the organization of giant fiber systems come from Eaton and Hackett's excellent chapter describing in detail the morphology, physiology, connectivity, and function of the Mauthner cell in teleost fishes. Finally, Wyman and colleagues describe a series of elegant studies of the effects of mutations on neural connectivity in a well-defined startle circuit responsible for triggering jump responses in the giant fiber system of *Drosophila*. But giant fibers are clearly not the whole story. In many species (fish and crayfish to name only two) escape responses that are not mediated by giant fibers are clearly possible. At least in crayfish, the functional significance of giant and non-giant responses reflects the tradeoff between speed on the one hand and control of direction on the other.

A second theme concerns the modern application of the "command neuron" concept. Two of the most widely accepted examples of this concept, the Mauthner cell and the crayfish lateral giants, are discussed in detail in several chapters (Krasne and Wine provide a particularly insightful commentary). Two important ideas that can be distilled from these chapters are, first, that commands are delivered and processed in a behavioral context that can ultimately sculpt the final motor output and, second, that commands are not simple "decision switches" that always produce all-or-none behavioral responses. Bennett provides several thoughtful examples that illustrate these ideas. He points out that earthworm shortening is dependent upon the firing frequency of giant neurons, that crayfish tail flip responses that are evoked by giant fibers are sup-

pressed if the animal is restrained by its carapace, and that fish tail flip responses that are evoked by repeated direct stimulation of the Mauthner cell decrease in a smoothly graded fashion (probably from progressive inhibition of motor neurons).

A third theme concerns the functional consequences of shared and specialized neural circuitry. An example is provided by the crayfish, in which it is now clear that the "motor giant" motor neurons are the private pathways of the giant axons (and are thus a specialized circuit) and that the "fast flexor" motor neurons are both the sole output of the non-giant system (specialized) and are also used by the giant system (shared). Mackie discusses evidence that a similar functional arrangement exists in the jellyfish *Aglantha*, in which the same motor neurons are activated by motor giants for escape and by another slow-conducting pathway. The locust, which provides another excellent example of circuit specialization, is discussed by Pearson and O'Shea. These authors compare motor interneurons in the jump circuitry (C and M neurons) and sensory interneurons in the movement detection system (LGMD and DCMD neurons) and suggest that, on the motor side, interneurons (through their specialized circuitry) generate single components of behavior and are only activated under specific conditions, whereas sensory systems extract a number of environmental features and can trigger a variety of state-dependent behaviors. Finally, in a highly instructive chapter Davis describes in detail the acoustic startle system of the rat. Remarkably, the time from stimulus onset to response in the limbs of the rat is only 6 to 8 milliseconds, indicating that only a few central synapses are involved. Davis and colleagues have established the primary neural circuit for the response and have shown that a number of different neurotransmitters can modulate acoustic startle at a variety of loci within the circuit. It is virtually certain that the motor neurons (as well as many interneurons) for the startle reflex are used for other behaviors as well; thus the magnitude of the startle response is subject to modulation by many other inputs, including stimuli immediately preceding the startle stimuli and previously learned responses.

The introductory chapter by Bullock and the concluding one by Bennett provide thought-provoking bookends for this volume. Both present important caveats concerning overgeneralization. For example, Bullock points out that not all rapid escape responses are startle responses, nor are they all mediated by

giant fibers. Moreover, not all startle responses lead to escape. Bennett emphasizes that the startle response might best be viewed as a trigger of many behaviors (the exact nature of which is based on prior experience) rather than as a command for a single behavior and cautions that fast systems may not be a cure-all for studying higher-order processes at a cellular level.

In conclusion, we return to the notion of general principles. In this volume have any emerged? In the strictest sense probably not, for our understanding of even these "simple" startle systems is still too limited. What is clear, however, is that anyone interested in the neural organization of behavior will find in the volume some superb examples in which to search for principles, general or otherwise.

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